[Third Edition.]

PATENT SPECIFICATION

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COMPLETE SPECIFICATION.

Improvements relating to the Emission and Reception of Submarine Waves.

I, PAUL LANGEVIN, of 10, rue Vauquelin, Paris (Seine), France, a citizen of the French Republic, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

In Specification No. 125,122, in the names of Chilowsky and the present applicant an apparatus has been described by which the directive emission and reception of elastic waves of high frequency in water are effected by means of electric oscillations and applications are described of these means for secret and directed submarine signalling, for detecting submarines and submarine mines and for protecting vessels against reefs, sandbanks, icebergs and collisions of any kind by utilising the echo produced or the shadow thrown by the obstacle to be detected.

The apparatus described utilises electrostatic or magnetic attractions in order to set into synchronous vibration a surface of which the dimensions are large relatively to the length in water of the emitted oscillations, the energy emitted being almost completely localised in a cone the axis of which is normal to the radiating surface and the sine of the semi-vertical angle of the cone proportional to the quotient of the length of the wave by the diameter of the surface, if the latter is circular.

The present invention consists in means which attain the same object by utilising the piezo-electric properties of quartz in order to obtain the transformation of electric oscillations of given frequency into elastic waves of the same frequency and *vice-versa*.

The work of P. and J. Curie has shown that the compression of a crystal of quartz in the direction of a binary axis produces an electric polarisation in this direction, and that inversely the establishment of an electric field in this direction is accompanied with a parallel contraction or dilatation according to the direction of the field.

The accompanying drawing shows examples of means for utilising this property.

Figs. 1, 2 and 3 show in transverse section three examples of a transmitting or receiving station or element of a station.

If a plate of quartz *a* having its faces perpendicular to a binary axis of a crystal is placed between the conducting armatures or coatings *b* and *c* so as to constitute a condenser forming part of an oscillating electric circuit *d* (Fig. 1), the production of electric oscillations in this circuit will be accompanied by synchronous contractions and dilatations of the plate of quartz capable of emitting in the water elastic waves of the same frequency. Inversely, the incident elastic waves will set in vibration the plate of quartz and the alternating electric polarisation which will result from this will act as an electromotive force in the condenser to set up in the oscillating circuit electric oscillations which are easily detected by the known methods of wireless telegraphy. The same apparatus can thus serve either as a transmitter or as a receiver of elastic waves of high frequency in the water. The smallness of the amplitudes corresponding to the propagation in the water of considerable energy under the form of elastic waves of high frequency is particularly adapted to

the order of magnitude of the piezo-electric deformations of quartz and the applicant has been able to obtain by this process emissions of elastic energy in water as high as 10 watts per square c/m.

The armature *c* for example of the quartz plate condenser by which the emission is effected in water can be suppressed if the submarine emission or reception takes place in conducting salt water, which acts as the external armature of the condenser. The apparatus takes the form shown in Fig. 2. *a* is the plate of quartz cut perpendicularly to a binary axis, *b* an insulated metallic plate forming the internal armature, and *f* a thin sheet of mica or other insulating material cemented on its edges to ensure water-tightness, and fixed to the plate of quartz by the interposition of a very thin layer of a substance such as resin or vaseline, or of petrol or the like which adheres by capillarity to the surface of the plate.

The internal face of the armature *b* can be in contact either with an insulating liquid or with the air within the box *e* which contains the condenser. In this latter case the emission of elastic waves will only take place on the side in contact with the water across the insulating sheet *f*.

The best conditions for the transformation of the electric waves into waves of mechanical compression or dilatation and *vice-versa* are realised when the combination of the plate of quartz and the armatures possesses in the direction of its thickness a natural period of vibration for emission equal to that of the generating electric oscillations, or for reception to that of the incident elastic waves. This condition is realised when the combination represents a half-wave plate for the frequency used. For a given amplitude of the alternating potential difference between the two armatures of the condenser the amplitude of the elastic waves emitted is a maximum when this condition of elastic resonance is realised. This condition, if the front of the incident waves is parallel to the surface of the condenser, effects the complete absorption of the incident elastic energy without reflection or transmission of the waves, the elastic energy being completely converted into electric energy which can be used in the receiving circuit.

In crystals of quartz which can be had in large quantities only suitable plates of very restricted dimensions can be obtained. It is, consequently, necessary to constitute the plate *a* of the condenser by placing together several plates having their binary axes parallel and in the same direction, obtaining in this way a mosaic of which the elements a^1, a^2 *etc.* are joined by an insulating material (vaseline, resin *etc.*) in order to avoid any leakage along the adjoining surfaces.

In order to diminish the quantity of quartz required and also to reduce the difference of potential necessary for the emission of a given power in wave form, the quartz is, preferably, in the form of a thin plate (single or mosaic plate), the rest of the half-wave plate being formed by a metal (bronze, steel or aluminium). This construction is shown in Fig. 3.

The efficiency of the quartz from the piezo-electric point of view being a maximum in the nodal (central) region of the half-wave plate, the best arrangement consists in placing the plate of quartz between two metallic plates *g*, g^1 of equal thickness, joined to the quartz by a suitable cement, and such that the natural vibration of the whole in the direction of its thickness shall be in resonance with the exciting electric oscillation for emission or the ultra-audible incident wave for reception. One of the two metallic plates, for example g^1, can form the external armature of the condenser with the surface which emits or receives the elastic waves in contact with the water, the other plate, *g*, which is insulated, constituting the internal armature of the condenser.

The insulated internal coating *g* will have its face opposite to the quartz in contact with air, if we wish the elastic radiation to be emitted by one side only; or in contact with an insulating liquid, such as oil or petrol if the emission is to take place by both faces of the condenser. The metallic plate g^1 constituting the external armature in contact with the water forms one of the faces of the box *h* which encloses the condenser.

The apparatus necessary for the emission and the reception of the ultra-audible waves by means of the quartz condenser comprises:

a) A station for producing undamped electric oscillations of high frequency of an amplitude which is either constant or periodically varied by alternators, arcs, or heterodyne lamps;

b) The oscillating emission circuit comprising the quartz condenser with the members necessary for supporting it and changing its direction either in the horizontal or the vertical planes;

c) The quartz condenser for reception,

which may also be the condenser for emission, just as the same antenna for the wireless telegraphy is utilised for both purposes;

d) The receiving circuits which can also, at least partially, serve for emission;

e) A valve amplifier analogous to those used in wireless telegraphy for telephonic reception, and a heterodyne generator producing beats of audible frequency in the telephone with the undamped oscillations received after their amplification and detection.

The arrangement according to the invention can be used not only for the detection of objects under water and the transmission of signals through water, but also for medical and other uses of elastic waves of high frequency.

Having now particularly described and ascertained the nature of my said invention, and in what manner the same is to be performed, I declare that what I claim is:—

1. A method of receiving and emitting waves of high frequency (above the limits of audibility) in water, in which the piezo-electric properties of quartz are used to cause changes of volume of a plate of quartz under the influence of the electric forces set up by the reception of the waves or, conversely, the changes of volume of the plate are used to set up electric forces which produce or control electric waves.

2. A method according to Claim 1 in which the plate of quartz is cut at right angles to a binary axis.

3. A method according to Claim 1 or 2 in which the natural period of vibration of the quartz plate in the direction of its thickness is the same as that of the waves received or transmitted.

4. Apparatus for carrying out the method according to any of the preceding claims, in which the plate is secured in a water-tight box, so that one surface of the plate is in contact with the surrounding water and a metallic armature secured to the other surface of the plate is in contact with air or with an insulating liquid contained in the box.

5. Apparatus according to Claims 1—3, in which metallic coatings are applied to one or both of the surfaces of the plate.

6. Apparatus according to Claims 1—3 in which the quartz plate is secured in a water-tight box and cemented to two metallic plates such that the natural period of the combination of the quartz and metallic plates is that of the waves to be received or emitted.

7. Apparatus according to any of the preceding claims in which the quartz plate is composed of several plates having their binary axes parallel and in the same direction.

8. Method and apparatus for emitting and receiving waves, substantially as described with reference to the accompanying drawings.

Dated this 30th day of June, 1920.

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Fig. 1.

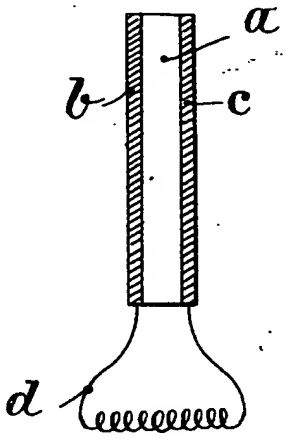


Fig. 2

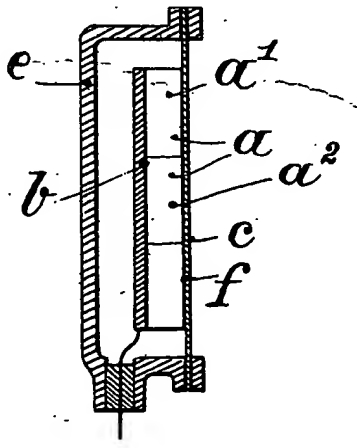
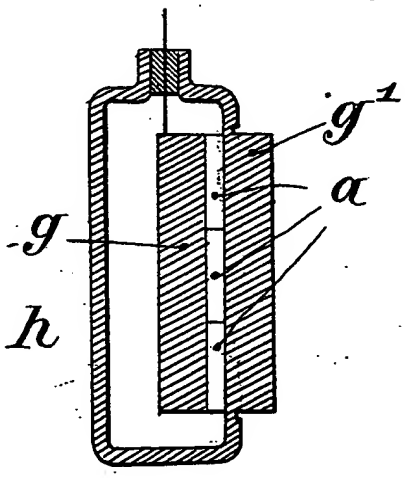


Fig. 3.



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